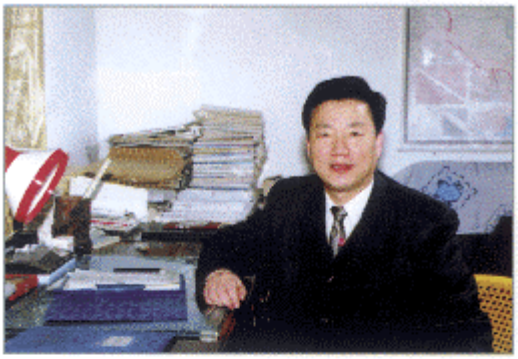
焦作矿区煤层气项目招商报告

Investment Opportunities in Coal Mine Methane Projects in Jiaozuo Mining Area

United States Environmental Protection Agency

China Coalbed Methane Clearinghouse

October 2001 Beijing



Chairman: Xin Shidu

President: Du Gonghui

Dear Colleague,

Jiaozuo Coal Group is one of the largest coal enterprises in China, which has a coal mining history of 50 years, and currently its annual coal production remains at 3 million ton or so. Up to the end of 2000, the total assets of the company were 2.28 billion yuan, and the sales revenue was 1.21 billion yuan in that year. The company has a total of 41,000 employees.

Jiaozuo mining are has rich coalbed methane resources. The total coalbed methane resources are estimated at about 173.3 billion m^3 to a depth of 2000m, with gas content ranging from 10 m^3/t to 38 m^3/t, and resources density of 230 million m^3/km^2. In 2000, pure methane recovered from 7 underground gas drainage systems was 11.42 million m^3 in total. Since 1995, 10 surface boreholes and 4 surface wells have been drilled in Jiaozuo mining area, with the highest single borehole gas production reaching 1307 m^3/d. Presently coal mine methane recovered from coal mining is mainly supplied to residential users in the urban area of Jiaozuo and the mining area, the annual methane used has reached 6 million m^3. In the other hand, the annual methane emissions from coal mining in Jiaozuo mining area are more than 60 million m^3.

Currently there are about 150,000 household users in the city of Jiaozuo, demanding 30 million m^3 of coalbed methane annually. The demand for natural gas will be increasing rapidly in the near future, and it is predicted that the demand for natural gas will increase from 240 million m^3 in 2003 to 564 million m^3 in 2010. Jiaozuo mining area features very favorable resources and market conditions for coalbed methane development. In the short term, attention should be paid to the perfecting of underground drainage systems and the start of the surface coalbed methane recovery project. Investors and developers from home and abroad are welcome to be involved in the coalbed methane projects in Jiaozuo mining area with the risk exploration or other cooperative modes.

Sincerely,

Xin Shidu
Chairman, Jiaozuo Coal Group

Executive Summary

Background

Jiaozuo Coal Group is one of the largest coal enterprises in China. The total confirmed capacity of coal production is 3.46 million tons/a. By 2015, the planned production will be 4.50 million tons /year. In 2000, the coal production of Jiaozuo Coal Group reached 2.99 million tons.

Jiaozuo mining area has abundant co3albed methane resources. The total coalbed methane resources within the depth of 2000m are 173.3 billion m^3. The coal-bearing area in Jiaozuo mining area is 350 k m^2. The gas content is averaged at 10 ~ 38 m^3/t. The average resource density is 231 million m^3/km^2. Coals in Jiaozuo mining area have many advantages such as good performance of adsorption, high gas content and high gas saturation, etc, which are favorable to coalbed methane development.

Currently Jiaozuo mining area has 7 high gassy or gas outburst coal mines. In 2000, the methane emissions from Jiaozuo mining area reached 60.16 million m^3. Up to 2000, 7 in-mine methane drainage systems have been built in Jiaozuo mining area, with a total methane drainage of 11.42 million m^3/a. If technical retrofit is done, the methane drainage amount could be increased up to 20 million m^3/a. CBM surface development tests have been also conducted. So far , 10 surface boreholes and other 4 coalbed methane surface wells have been drilled. The peak production of a surface borehole reached 1307 m^3/d, which shows a commercial potential for surface coalbed methane development.

Currently the annual methane utilization in Jiaozuo mining area is approximately 6 million m^3, which accounts for 53% of the total methane drained. At present, the demand of residential use in Jiaozuo City is 30 million m^3/a. It is predicted by experts that by the year of 2010, the total demands for natural gas in Jiaozuo City will reach 564 million m^3 and 100 million m^3, respectively.

Investment Opportunities

The Jiaozuo Coal Group has identified two coalbed methane projects that would improve mine safety and provide revenue from the sales of coalbed methane. Following is a summary of the two potential CBM/CMM projects for which the Jiaozuo Coal Group is seeking investment:

(1) *Jiaozuo CBM residential use project.* Currently, CBM drainage in Jiaozuo mining area is mainly aimed at coal mine safety. Jiaozuo mining area now has 4 coal mines from which coalbed methane recovered is supplied to the city residents. This project will expand the drainage amount and increase the methane utilization from current 6 million m^3/a to 20 million m^3/a. The project will include the retrofitting and perfecting of the existing in-mine drainage systems, set up new gas holders, gas transport and distribution pipelines and other necessary facilities. Total investment of the project is 53 million yuan (US$ 6.39

million) including the investment 30 million yuan (US$3.61 million) of the existing gas transport and distribution system. For the newly added investment , Jiaozuo Coal Group will contribute 30% of the project investment and the remaining 70% will be raised through loans or outside investment. Based on the total investment of 53 million yuan, the estimated net present value (NPV) would be 19.79 million yuan (US$2.38 million), the internal rate of return (IRR) would be 23%, and the payback time would be 7 years. Jiaozuo Coal Group proposes to start the project in 2002 and anticipates that it would be fully implemented by the end of 2003.

(2) Encun CBM surface development project. The project will use vertical well method to recover coalbed methane in Encun Block. The project includes the construction of 100 surface wells, and the annual gas production is 100 million m^3 . The service life of the project is 30 years. Coalbed methane recovered from the project will be mainly supplied to some major industrial users in Jiaozuo City. Project engineering will consist of surface well drilling and construction of the CBM gathering system. With regard to total investment 200 million yuan, Jiaozuo Coal Group will be responsible for the raising of 35% of the total, and the remaining is expected to obtain from outside investment. Based on the total investment of 200 million yuan, the estimated NPV of the project would be 98.66 million yuan (US$11.89 million) , the IRR would be 24%, and the payback time would be 8 years. Jiaozuo Coal Group proposes to start the project, and anticipates that it would be fully implemented by 2005.

Jiaozuo Coal Group recognizes that investment in these projects may have certain risks. The variation of CBM price and CBM production may affect the project economics. Jiaozuo Coal Group is ready to help determine the market risk for potential foreign investors and willing to answer any important question investors may concern.

Jiaozuo Coal Group is also ready to consider every possible way for cooperation and various means for capital raising to carry out the above projects. Representatives of banks, foreign companies and overseas financial organizations are welcomed to review the attached marketing package and contact us for more information.

Zhang Guangde
Chief Engineer
Jiaozuo Coal Group
239 Jianfanzhonglu, Jiaozuo
Henan 454002, China
Tel: 0086-391-3531087

1. Overview

Jiaozuo mining area is located in the northwest part of Henan province, which traverses Xiuwu county and Huixian county of Jiaozuo city. The mining area is 60 km long from east to west. The coal-bearing area is 350 k m^2. The proven coal reserves are 2.665 billion tons. Jiaozuo mining area enjoys very well developed transportation systems. The Xinxiang railroad station of Jingguang trunk railway line is just 63 km away to the east of the mining area. It is 140 km from west of the mining area to the Luoyang railway station of Longhai trunk railway line. Xinjiao railway and Jiaotai railway go through the mining area (see Fig.1).

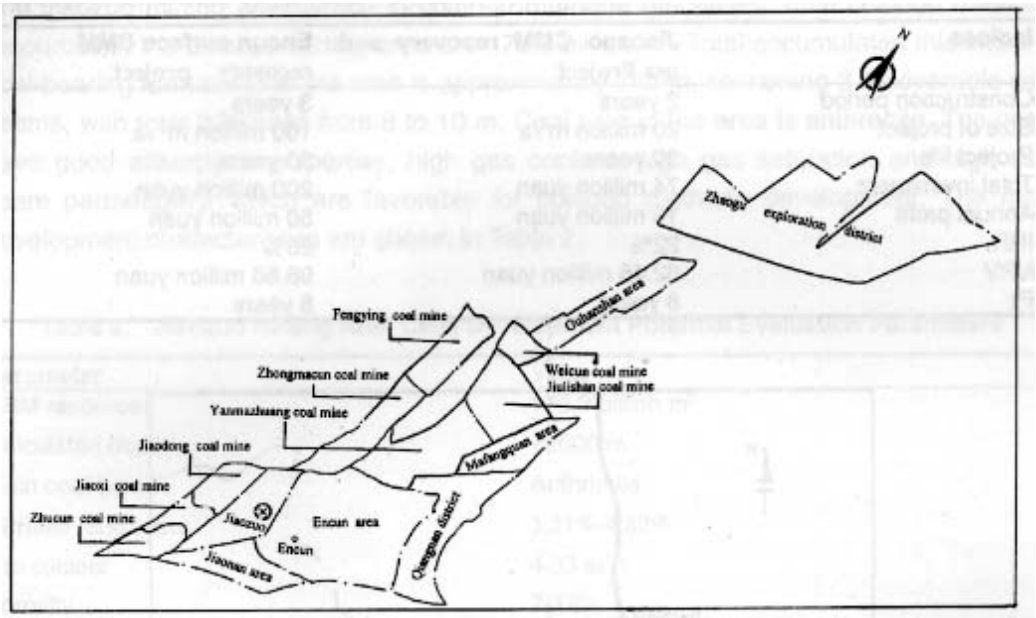


Fig. 1 Location of Jiaozuo Mining Area

The Jiaozuo coal mining area is rich in coalbed methane resources. with total resources as high as 173.3 billion m^3, and reservoi r conditions are favorable for development.

Currently only underground drainage is used in Jaozuo mining area. Total methane recovery reached 11.41 million m^3 in 2000. In 1990s, 4 surface coalbed methane wells were drilled and tested.

For the near future, two projects are proposed in Jiaozuo mining area including a CMM recovery and residential use project and a CBM surface recovery project. The purpose of the above two projects is to obtain economic benefit from sales of the gas recovered, while improving safety conditions in coal mines. Major technical economic indices of the two CMM projects are shown in Table 1.

2. Introduction to the Enterprise

Jiaozuo Coal Mining Administration was founded in 1949. In March of the year 2000 it

was restructured as Jiaozuo Coal Group, which is one of the large coal enterprises in China. Jiaozuo Coal Group has 7 active coal mines with the confirmed production capacity 3.46 million t/a. In the end of 2000 Jiaozuo Coal Industry Group had total assets of RMB 2.28 billion yuan and 41,000 employees. The annual revenue reached RMB 1,21 billion yuan.

Table 1. Major Technical and Economic Indices of Coal Mine Methane Projects

Indices	Jiaozuo CMM recovery and use Project	Encun surface CMM recovery project
Construction period	2 years	3 years
Size of project	20 million m^3/a	100 million m^3 /a
Project life	30 years	30 years
Total investment	53 million yuan	200 million yuan
Annual profit	14 million yuan	50 million yuan
IRR	23%	23%
NPV	19.79 million yuan	98.66 million yuan
Pt	7 years	8 years

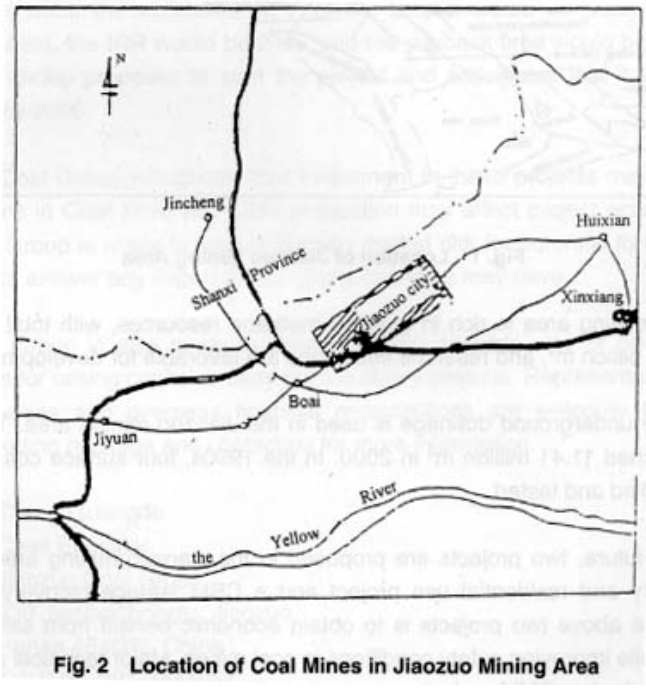


Fig. 2 Location of Coal Mines in Jiaozuo Mining Area

The Jiaozuo Coal Group has a coal production history for over 50 years. At present, the annual coal production is always around 3 million tons. In 2000 the production reached 2.99 million tons. In accordance with the plan for coal production of Jiaozuo Coal Group, the coal production will be 3.30 million t/a by the year of 2010, and will reach 4.50 million t/a by 2015. The coal mine distribution of the Jiaozuo mining area is shown in Fig. 2.

3. Coalbed Methane Resources

Jiaozuo mining area is rich in coalbed methane resources. The total coalbed methane resources in Jiaozuo mining area within the depth of 2000 m are 173.3 billion m^3. The total accumulated thickness of coal-bearing formation in Jiaozuo mining area is approximately 740 m containing 3 recoverable coal seams. Total coal seam thickness is from 8 to 10 m. Coal type in the mining area is anthracite. Coal seams of Jiaozuo mining area is noted for its good adsorption property, high gas content, high gas saturation and high coal seam permeability, which are favorable for coalbed methane development. The main development characteristics are shown in Table 2.

Table 2 Jiaozuo Mining Area CMM Development Potential Evaluation Parameters

Parameter	Value
CBM resources	173.3 billion m^3
Calculated depth	<2000m
Main coal type	Anthracite
Vitrinite reflectance	3.21%-4.82%
Gas content	4-33 m^3/t
Porosity	7-12%
Maximum absorption capacity	38 m^3/t
Absorption pressure	0.5-1.0MPa
Permeability	0-3.6 md
Reservoir pressure	0.88-11.0MPa
Gas saturation	60-99%

4. Coal Mine Methane Development and Utilization

4.1 Coal Mine Methane Emission, Recovery and use

Currently Jiaozuo mining area has 7 active mines, all of which are high gassy or gas outburst ones. In 2000, the annual methane emissions in the mining area reached 60.16 million m^3.

The coalbed methane recovery in Jiaozuo mining area started in 1964. In 1990, the CBM drainage amount exceeded 10 million m^3. By 2000, 7 gas drainage systems were set up in Jiaozuo mining area. The CBM drainage amount reached 11.42 million m^3 in 2000 . The in-seam boreholes and cross-measure boreholes are mainly employed to drain coal mine methane.

The CBM surface recovery started during period of “the 9th Five Year Plan”. Since that time, 10 surface boreholes were drilled in Zhongmacun Mine. The average single borehole gas production was 195 ~ 613 m^3/d. After water scouring for the borehole and fracturing, the coalbed methane production increased rapidly. The gas production from No. 5 borehole reached 1307 m^3/d. In 1995, Zhongyuan Oil Field and Jiaozuo

Coal Group agreed to jointly develop coalbed methane resources in Guhanshan coal field of Jiaozuo mining area. Under the cooperative project, 4 surface wells were drilled, and well testing and trial gas production tests were also performed.

Coalbed methane recovered in Jiaozuo mining area is mainly used as residential fuel. In 2000, approximately 6 million m^3 of pure methane was utilized. At present, 4 coal mines of Jaiozuo Coal Group supply gas to the Jiaozuo Gas Co.. The total length of the gas pipeline is 24.8 km.

A medium sized coalbed methane residential use system has been established in Jiaozuo mining area. A gas holder of 10,000 m^3 and a gas holder of 5000 m^3 has been constructed in Zhucun Mine and Jiulishan Mine, respectively. A 100 m^3 of compressed tank was also set up in Weicun Mine. And gas was also transported to the gas holder in Jiulishan Mine. Additionally, a 30,000 m^3 of gas holder and a 54,000 m^3 of gas holder were established in Jiaozuo Gas Co.. At present, 41,500 households are using coalbed methane as fuel gas. The annual mixed gas consumption is 20 million m^3, or the pure methane of 6 million m^3. The mixed gas price for the end user is RMB 0.50 yuan/ m^3 (30% CH_4).

4.2 Analysis on Coalbed Methane Production Capacity

Currently the annual coalbed methane emissions in Jiaozuo mining area has reached 60.16 million m^3. With the mining depth increasing and coal production going up, the coalbed methane emissions in Jiaozuo mining area will further increase. At present, coalbed methane recovery systems have been built in 7 coal mines of Jiaozuo mining area. However, the drainage rate is very low, less than 20%. According to the plan for Jiaozuo mining area coalbed methane development, by the year of 2006 it is expected that the underground coal mine methane production could reach 20 million m^3 annually through improving CMM drainage method and perfecting surface CMM utilization facilities.

The coalbed methane surface development will be mainly concentrated at Encun Block, Yanmazhuang-Jiulishan Block and Guhanshan Block. Conditions of coalbed methane resources in Encun Block is the best. And it is also close to potential users .Encun Block is located 5 km in the south west of Jiaozuo city covering an area of 79 k m^3. The Block's CBM resources are as high as 28.8 billion m3. Assuming that the surface recovery project needs to drill 100 CBM surface wells with a single well output 3000 m^3/d, the annual gas production would be 100 million m^3.

5. Coal Mine Methane Residential Use Project in Jiaozuo Mining Area

5.1 Project Description

The project is aimed to utilize the methane drained from in-mine drainage systems in 5 coal mines. Coal mine methane drained will be supplied to household users in Jiaozuo city and mining area through pipelines linked to each mine. The project size for pure methane supply is 20 million m^3/year, or mixed gas 57 million m^3/year (35%

CH4). The project will increase CMM recovery up to 20 million m^3/a by perfecting the recovery and utilization system and improving drainage methods. The project engineering will include the gas drainage engineering, the construction of 2 gas holders each 20,000 m^3, and 5 km of gas pipelines and necessary equipment and facilities. The total project investment is RMB 53 million yuan including the existing transport and distribution systems. The service life of the project is 30 years.

Since Hanwang Mine, Fengying Mine and Zhucun Mine will be closed soon, the CMM recovery and utilization for Macun Mine and other 4 coal mines will be mainly taken into account. Table 3 shows the coalbed methane resource conditions and service life for candidate coal mines.

All the above 5 coal mines have permanent CMM recovery systems. In 2000, the total CMM drainage was 10 million m^3, however, the average drainage rate was only 19%. Therefore, there will be large potential for the increase of CMM drainage. With the increase of the depth of coal mining and Guhanshan Coal Mine being completed and put into operation, the coalbed methane emissions from the above coal mines will further increase.

Table 3 CMM Resource Conditions and Service Life for Candidate Coal Mines.

Coal Mine	Coal Resources (million tons)	CMM Resources (billion m^3)	Average Gas Content (m^3/t)	Service Life (year)
Zhongmacun	92.09	1.8421	15	64
Yanmazhuang	125.02	2.750	11	42
Jiulishan	126.26	3.030	9	64
Weicun	17.07	0.386	11	16
Guhanshan	156.38	3.753	15	60
Total	516.82	11.761		

5.2 Coal Mine Methane Market

Coal is now dominating over the energy consumption market in Jiaozuo city. Coal consumption accounts for more than 90% of the total. Such unreasonable energy structure has resulted in serious air pollution. Therefore, replacing partial coal by coal mine methane as fuel can effectively improve local air quality.

The CMM market in Jiaozuo will be mainly residential use fuel and industrial fuel. Jiaozuo mining area has sufficient power supply. Electricity generated in CMM power plants have to be supplied to the power grid. The grid power price is only 0.27 yuan/kWh. However, there are big demands for coal mine methane in Jiaozuo gas

market and good price can be obtained. The CMM price for residential use has reached 0.50 yuan/ m^3 (30%CH4). Currently Jiaozuo city has 150,000 potential residential users. If all the residential users are fueled by coal mine methane, the annual demand for the mixed gas will be 100 million m^3, or 30 million m^3 of pure methane. Therefore, the main purpose of the project is to supply gas to residents in Jiaozuo city and mining area.

5.3 Project Options

Currently two gas drainage methods are widely used in the mining area, i.e. pre-drainage from the working coal seam, and draining gas while coal is mined. This method has a low drainage rate, and the concentration of the coal mine methane drained is low. Therefore, during the construction of the gas drainage systems, it is necessary to use new drainage technologies such as in-mine horizontal long hole drilling and gob well drainage, etc. so as to increase the efficiency of gas drainage, and raise the CMM concentration through improving the borehole sealing method and strengthening the management to the underground gas pipelines.

The main purpose of the project is to supply gas to residents in Jiaozuo City and mining area. At present, the coal mine methane drained from Jiulishan Mine, Yanmazhuang Mine, Zhongmacun Mine and Weicun Mine is transported, via a compressed tank, to three gas holders, of which the gas holder of 5000 m^3 is in Jiulishan Mine. Jiaozuo Gas Co. has a gas holder of 30,000 m^3 and a gas holder of 54,000 m^3. This project will make full use of the existing transport and distribution systems, and will build 2 new gas holders with 20,000 m^3 each in Macun and Zhongzhan, respectively. A gas compressing station (in Guhanshan Mine), and 5 km of gas pipeline will also be built.

Coal mine methane drained from each coal mine will be firstly compressed, and then be transported to each gas holder from which the gas will be supplied to residents, via the medium and low pressure gas supply system.

5.4 Project Construction

The project is planed to start construction in 2003. It is expected that the capacity of gas drainage and supply reach 20 million m^3/a, or mixed gas 57 million m^3 by 2005. With regard to the project funding, the loan application, investment, fund raising and self-funding and other forms will be applied to get funds for the project construction. The construction period of the project is 2 years. Major technical and economic indices of the project are shown in Table 4.

5.5 Financial Evaluatin

1) Analysis on Financial Profitability

The discounted cash flow method is used to analyze the profitability of the CMM project. Now assuming that the real dicount rate is 12%, inflation rate is 3%, the income tax rate for the first 5 years is 0%, after the fifth year is 33%. The hosehold use

gas price in Jiaozuo City is 1.40 yuan/ m^3 of pure methane, and the total cost 0.70 yuan/ m^3, which includes all the expenses incurred from CMM pump station to end users. Total investment of the project is 53 million yuan, of which additional investment is 23 million yuan, the equivalent value of the existing CMM transport and distribution system is 30 million yuan. Through calculations, major technical and economic indices of the project is shown in Table 5.

Table 4. Major Technical and Economic Indices of the CMM Residential Use Project In Jiaozuo Mining Area

Item	Unit	Quantity
Methane drainage	million m^3/a	20
Transport capacity	million m^3/a	20
CH_4 concentration of mixture gas	%	35
Capacity of new gas holders	1000 m^3	40
Additional gas pipelines	km	5

Table 5. CMM Residential Use Project in Jaiozuo Mining Area

Item	Quantity
Total Investment	53 million yuan
Project Scale	20 million m^3/a (pure methane)
Transport and Distribution Capacity	57 million m^3/a (mixed gas, 35%CH4)
Total Cost	0.70 yuan/ m^3 (pure methane)
Gas price for residential user	1.40 yuan/ m^3 (pure methane)
IRR	23%
NPV	19.79 million yuan
Pt	7 years

5.6 Energy Savings and Environment Protection Results

This project uses coal mine methane as fuel in place of coal. The thermal efficiency can be raised and the greenhouse gas emission can be greatly reduced. When coal mine methane is used as residential fuel, the CMM thermal efficiency will be 4 times that of coal. One m^3 of methane gas can replace 4.72 kg of coal equivalent. After the project is put into operation, 94,000 tons of coal equivalent can be saved, or 83,000 tons of local coal (the raw coal ash content, sulfur content and heating value is 17%, 0.34% and 8200kcal/kg, respectively). The implementation of the project will prevent environmental pollution caused by coal combustion, see Table 6.

With regard to the reduction of the greenhouse gas emissions, utilizing coal mine methane as fuel for residential use could reduce 20 million m^3 of methane (14,000 tons) emissions, or reduce emissions of CO_2 294,000 tons. Burning 20 million m^3 of methane will emit 39,000 tons of CO_2. On the other hand, this project will save 94,000

tons of coal equivalent. Burning per kg coal equivalent will emit 2.66 kg of CO_2. Therefore, the project could avoid the emissions of CO_2 250,000 tons caused by coal combustion. In general, this project could actually reduce emissions of 507,000 tons of CO_2.

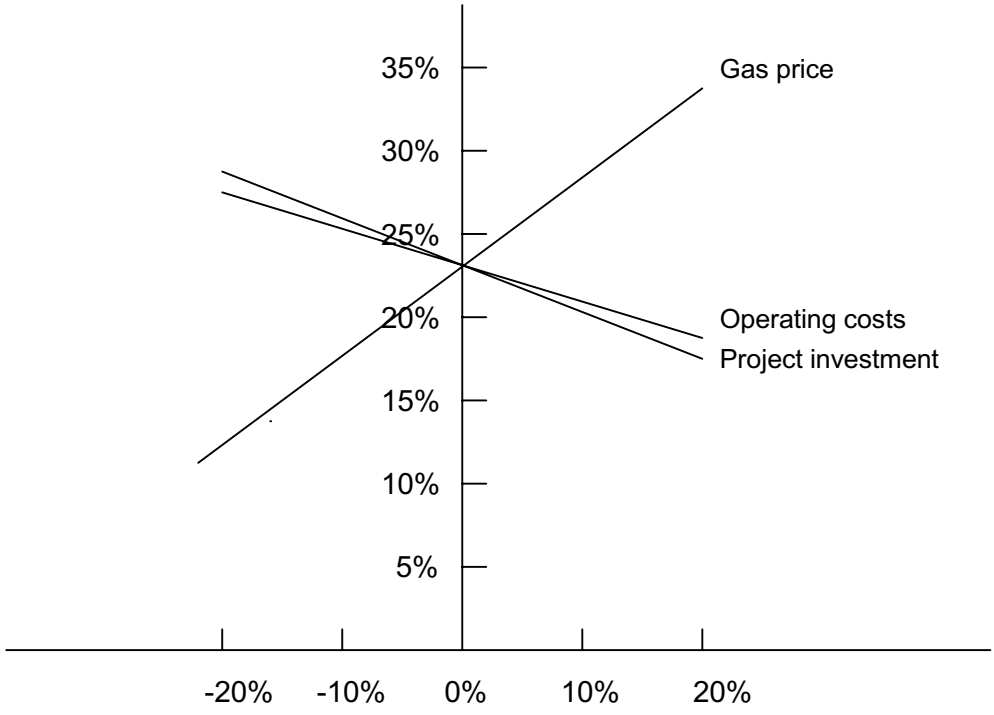


Fig. 3 Sensitivity Curve of Jiaozuo CMM Recovery and Use Project

Table 6. Emissions Reductions of Jiaozuo CMM Recovery and Use Project

Type of Emissions	Amount reduced annually
Sulfur dioxide	4515 t
Fly ash	2822 t
Slag	11300 t
Greenhouse gases (CO_2 equivalent)	507,000 t

The entire operating cost of the project is 0.7 yuan/ m^3, the annual operating cost is 14 million yuan. The CO_2 emission reduction of the project will be as high as 507,000 tons, thus the cost for CO_2 emission reduction is as below:

1400/50.7 = 27.6 (yuan/ton CO_2)

5.7 Analysis of the obstacles to Project Implementation

1) Lack of Funds

In the past few years, due to coal supply over demand, coal enterprises encountered economic difficuty. It is hard for coal enterprises to have extra funds for CMM project. Jiaozuo CMM recovery and utilization project requires additional investment 23 million yuan, of which 16.10 million yuan needs a bank loan or outside investment from

domestic and foreign companies.

2) Lack of Advanced Technology

In order to promote CMM development and utilization in Jiaozuo mining area, it is necessary to introduce the technologies of surface face vertical well, gob well, in-mine horizontal long hole and other technologies to increase CMM drainage efficiency. In the aspect of underground gas drainage, the existing in-mine borehole and cross-measure borehole has very low drainage efficiency, averaged at only 20%. Therefore, introduction of new technologies will notably increase CMM production.

3) *CMM Price*

Currently Jaiozuo Coal Group is in charge of CMM production， and Jiaozuo Gas Co. is responsible for the gas supply. However, there is too much difference between the CMM wellhead price and end user price. The CMM price at the gas holder entrance is just 0.20 yuan/ m^3 (mixed gas 35% CH4), but the end user price is as high as 0.50 yuan/ m^3 (mixed gas). Such big price difference will cause negative influence on the coal mine methane production of Jiaozuo Coal Group.

5.7 Project Implementation: Demand and Ready Conditions

Partners desired for the project mainly include investors and technology providers. Since the total additional investment is 23 million yuan, outside investment is required to the implementation of the project. Technical requirements mainly include the introduction and use of directional horizontal long holes and gob wells.

At present, the following favorable conditions exists for the project:

(1) Rich coalbed methane resources in the Jiaozuo mining area and generally favorable conditions for development;

(2) A coal mine methane recovery and use system has been in operation for several years, the system can be used for transport of the increased coal mine methane production;

(3) There is a huge demand for coal mine methane in the city of Jiaozuo, all the methane recovered can be supplied to household users.

5.8 Risk Analysis

Risks of this project mainly lies in technical and market aspects. Application of directional drilling long holes and gob wells will have to be tested and popularized. Coal production of these mines may also affect the coal mine methane production. As to the market risk, the price and supply of natural gas from Tarim , Xinjiang may affect the price of coal mine methane, so as to affect the economics of the project.

6. CBM Surface Development Project in Encun

6.1 Project Description

The surface vertical well will be used for the Encun surface coalbed methane recovery project. The project needs to drill 100 surface wells with annual gas

production of 100 million m^3. The project service is 30 years. Conditions for the market and resources of Encun Block are favorable for coalbed methane development.

Encun Block is located 5 km south east of Jiaozuo City. The general structure of the Block is an axial syncline going nearly from east to west. And there are several big-angle positive faults developed. The CBM reservoirs are No.2.1 and No.1.1 coal seams. The thickness of No.2.1 coal seam ranges from 0.71 to 12.69 m, generally 3 ~ 8 m, on the average 6.26 m. Coal type is anthracite. Coal cleats are not so well-developed. After fracturing, the coal seam permeability can be increased greatly. Coal reservoir's Langmuir volume is 59.5 m^3/t, Langmuir pressure is 0.91 MPa. The average gas content of coal seams is 25.6 ~ 32 m^3/t. The CBM resources in this area are 28.778 billion m^3. The resource density in the whole area is as high as 364 million m^3/k m^3.

Encun Coal Mine with designed capacity of 1.20 million t /a will be put into operation in 2015. Gas disasters will be thoroughly eliminated through pre-drainage.

6.2 Development Options

CBM surface development technology, the well completion technology for two coal seams and coal seam stimulation technology to increase CBM production will be used for the Encun Block CBM development.

Based on the characteristics of the coal seam development, the target seams are mainly No.2.1 and No.1.1 coal seams. Therefore, the multi-seam casing and perforation technology will be used for well completion , and water fracturing is adopted for the coal seam fracturing.

According to the conditions of the coal reservoir in Encun Block, the average daily production of the CBM well could reach 3000 m^3/d. To achieve the production of 270,000 m^3/d and annual gas production 100 million m^3, 90 ~ 100 wells need to be drilled. If a well covers 0.24 k m^2, then 100 wells will require at least 24 k m^2 of the development area. Considering there are probably rivers and residential area, the actual area of the development block should be more than 24 k m^2.

Coalbed methane development in Encun Block will be carried out in stages. At first 5 to 10 wells will be drilled in the first two years for gas production and test so as to collect sufficient parameters. If the first stage development trial is successful, it will go to the next stage for rolling development. The remaining 90 wells will be completed in 3 years.

6.3 Coalbed Methane Market

Coalbed methane recovered by the project will be supplied to major industrial users in Jiaozuo City through the gas transporting and distribution system. The first priority for

the industrial users should be the Jiaozuo Chemical Plant and the Jiaozuo Chemical Power Group. By 2005, the natural gas demands of the above two users will reach 100 million m^3. The Chemical Plant is 12 km away from Encun Block and the Chemical Power Group is 15 km away from Encun Block. Based on investigation, the acceptable gas price to the above two enterprises is 1.30 yuan/ m^3.

In addition, after completion of the project "West-East Gas Pipelines Project", the natural gas price at the exit in Jiaozuo is 1.20 yuan/ m^3. Therefore, CBM price in the future will be about 1.20 yuan/ m^3. With people's living standard going up and stricter requirements to the environment protection, demands for natural gas in Jiaozuo City will increase rapidly. It is predicted by experts that the natural gas demand in Jiaozuo City will be increased from 240 million m^3 in 2003 to 564 million m^3 in 2010. Major natural gas users and their predicted demands in Jiaozuo City is shown in Table 7.

Table 7. Major Natural Gas Users and Predicted Demands

Main users	Demand for natural gas (million m^3)	
	2005	2010
Chemical Plant	80.00	80.00
Chemical Power Group	16.80	29.40
Xinmei Company	10.00	10.00
Zhongyuan Axle Factory	4.00	20.00
Residential Use	51.95	100.28

6.4 Project Construction

The Encun Surface CMM Recovery Project will start in 2002, with a designed production capacity of 100 million m^3. The effective service life of the coalbed methane well is averaged at 20 years. The exploration of the project is 2 years and its construction period is 3 years. When all the surface wells are put into operation, it is expected that the gas production would reach 100 million m^3. For detailed technical and economic indices of the project, see table 8.

Table 8. Major Technical and Economic Indices of Encun CBM Surface Recovery Project

Item	Amount
Total Investment	200 million yuan
Project size	200 million yuan/a
Number of production well	100
Single well investment	1.70 million yuan
Surface pipeline investment for single well	300,000 yuan
Well spacing	0.24 k m^2
Single well production	3000 m^3/d

6.5 Financial Analysis

The total project investment contains the investment for exploration and assessment,

the investment of the development and engineering and the investment of the surface facilities and engineering. Based on the summary for the surface CBM well construction in Jiaozuo mining area done by Zhongyuan Oil Field, the CBM drilling and well completion costs were approximately 1.70 million yuan including the surface gas drainage facilities. On the average, the investment for a single well gas pipeline was 300,000 yuan. Total investment within the project construction period is approximately 200 million yuan. The CBM production cost includes the depreciation cost and operating costs. Assuming depreciation period is 10 years, total amount of depreciation is 2 million yuan, then the annual depreciation cost for a single well is 200,000 yuan. On the other hand, the operating costs for a single well is 300,000 yuan including salary, power charge, management and maintenance expenses and land lease fee, etc. Within the stable production period, the annual production per well is 1.0 million m^3. Therefore, the CBM production cost is approximately 0.5 yuan/ m^3. Based on the current status of the gas fuel market, the CBM wellhead price could be set at 1.00 yuan/ m^3.

Regarding the project investment, 65% of the project investment is expected to get from bank loan or obtain investment from foreign companies. The total project investment is 130 million yuan. The remaining 35% investment will be raised by Jiaozuo Coal Group. The loan interest rate is 6.5%.

The discounted cash flow method is used to analyze the profitability of the CBM project. Now assuming the real discount rate is 12%, the inflation rate is 3%. The value-added tax of CBM production for the project is 5%. The income tax is 33%. CBM wellhead price is 1.00 yuan/m^3. Through calculations, the project technical and economic indices are shown in Table 9.

Table 9. Economic Evaluation Results on Encun CBM Surface Recovery Project

Item	Amount
Total Investment	200 million yuan
Production size	100 million yuan
CBM wellhead price	1.20 yuan/m3
IRR	23%
NPV	98.66 million yuan
Pt	7 years

Financial analysis results show that the project is very profitable, and the sensitivity analysis (Fig.4) indicates that wellhead price is the most significant factor affecting the project economics.

6.6 Analysis of Emissions Reduction

Coalbed methane recovered in the project will be used to replace coal as industrial fuel. Calculated on heating value basis regardless of thermal efficiency, the project will annually produce 100 million m^3 coalbed methane, which could replace 118,100 tons

of coal equivalent, or raw coal 103,700 t. Therefore, using coalbed methane instead of raw coal will remarkably reduce pollution caused by coal burning. See Table 10.

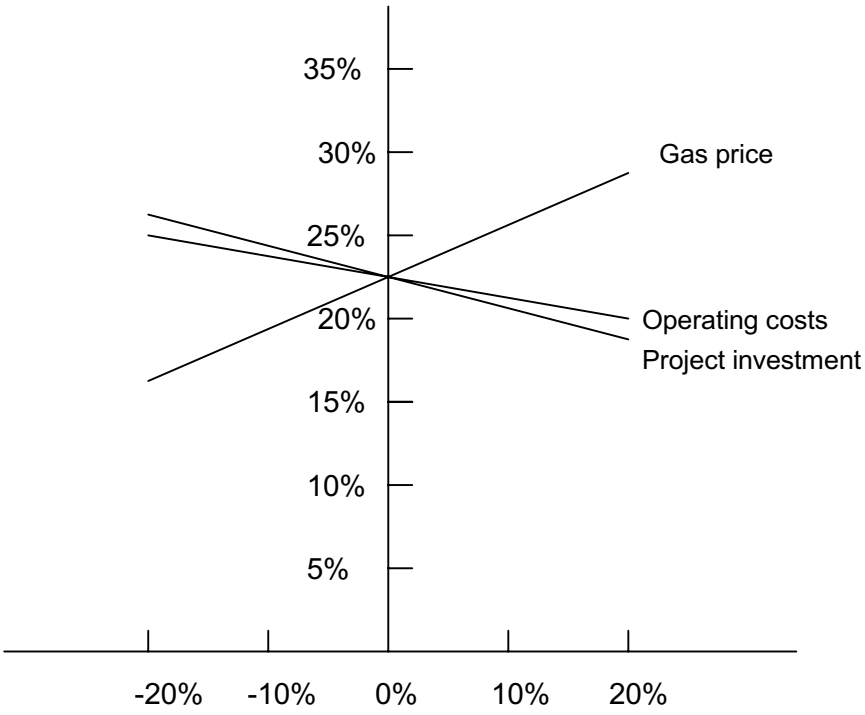


Fig. 4 Sensitivity Curve of Encun CBM Surface Recovery Project

Using coalbed methane instead of coal as fuel can remarkably reduce the greenhouse gas emissions. Burning 100 million $m^3$of coalbed methane will have an emission of 195,000 tons of CO_2. However, burning 118,100 tons of coal equivalent will release 314,000 tons of CO_2. Therefore, the project could reduce emissions of 119,000 tons of CO_2.

Table 10. Emission Reductions of the Encun CBM Surface Recovery Project

Type of Emissions	Amount reduced annually
Sulfur dioxide	5641 t
Fly ash	3526 t
Slag	2261 t
Green house gas reduction	119,000 t CO_2 equivalent

The wellhead cost of the CBM production is 0.50 yuan/ m^3. The annual operating costs are 50 million yuan. Thus, the cost for CO_2 emission reduction is as below:

$$5000/19.5 = 256 \quad (\text{yuan/t } CO_2)$$

6.6 Analysis of Obstacles to Project Implementation

(1) Lack of Funds

The project will require a huge amount of investment, and Jiaozuo Coal Group does not have enough money to implement the project. Bank loans or outside investment is urgently needed to start the project, so as to promote the development of coalbed methane industry in Jiaozuo coal mining area.

(2) Lack of Technologies

Although the Zhongyuan Oil Field have drilled 4 surface wells in Jiaozuo mining area, but all the wells failed to produce coalbed methane due to technical and economic reasons. Anyway, the surface recovery technology needs to be tested in the Encun Block, so as to provide basic engineering parameters for further commercial development.

6.7 Requirements of the Project and Conditions in Places

Both investors and technology providers are required for the implementation of the project. Investors could contribute 65% of the total project investment, and the technology providers are welcome to demonstrate the surface recovery technology and provide necessary technical training.

Resources available to the implementation of this project includes:

(1) Jiaozuo Coal Group could contribute 35% of the total investment of the project, and can provide skilled technical personnel to the implementation of the project.
(2) The coalbed methane market is huge enough for the project, and the coalbed methane sales prices can be kept at high level;
(3) Both local government and Jiaozuo Coal Group actively support the establishment of the project.

6.7 Risk Analysis

Risks involved in this project mainly include technical issue. As surface coalbed methane recovery technology has not been successfully demonstrated so far, it needs to perform necessary tests to confirm if the designed single well gas production level can be achieved.

7. Conclusions

(1)Jiaozuo mining area has abundant CBM resources. Total resources in the whole area is 173.3 billion m^3. The coalbed methane content in Jiaozuo mining area is 10 – 38 m^3/t. Gas saturation and coal seam permeability is high. The resource density is also high, which are favorable to coalbed methane development.

(2) Jiaozuo mining area is situated in China's middle part plain where is in shortage of nature gas supply. The nearby Jiaozuo, Zhengzhou, Luoyang and other cities have large demands for fuel gas. Therefore, the coalbed methane market conditions are pretty good here. Additionally, several coal mines in Jiaozuo mining area have had the gas pipelines connected, and CBM residential use

system has been built to some extent, which has created a good condition for CBM development and utilization for the next step.

(3) There is large potential for CBM production in Jiaozuo mining area. It will make the underground drainage capacity increase to 20 million m^3 annually if the existing drainage system is retrofitted and new drainage system is built. After the completion of Encun surface CBM recovery project, it will achieve the annual production capacity of 100 million m^3.

(4) Based on the potential of CBM production and market conditions in Jiaozuo mining area, the priority to the coalbed methane in Jiaozuo would be residential use and used as industrial fuel. All coalbed methane produced in the mining area is supplied to users in Jiaozuo City.

(5) The CBM project in Jiaozuo mining area can be carried out through PSC contract, joint venture and other methods. With regard to the project funding, financial source would include foreign investment, fund raising by enterprise itself and bank loans, etc.

(6) Currently, the main obstacles to the project implementation are lack of funds, technology and reasonable CBM wellhead price. The risks to the project implementation include the application of new CBM recovery technologies and the changes of CBM sales prices.

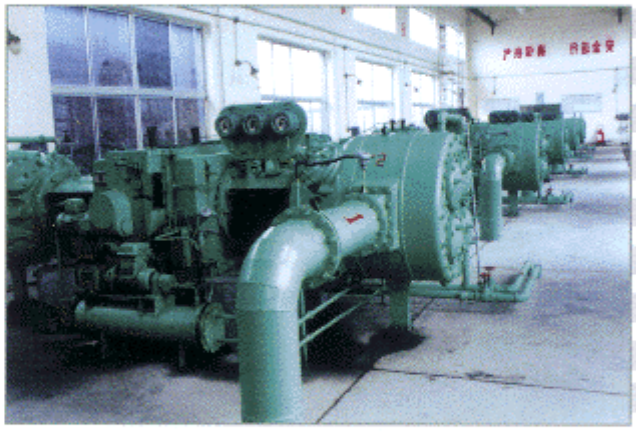
In order to speed up the implementation of CBM projects and promote the development of CBM industry in Jiaozuo mining area, suggestions are made as follows:

(1) Introduce foreign funds and techniques to speed up the implementation of CBM projects in Jiaozuo mining area. It is necessary to combine coal production with coalbed methane development and work out a plan for comprehensive development.

(2) Establish a special organization in charge of CBM development and utilization to unify the management of both CBM surface development and in-mine drainage.

(3) Jiaozuo City should be the priority for coalbed methane market. Efforts should be made to develop more and more household users, commercial users and big sized industrial users.

There are 7 underground gas drainage systems in operation in Jiaozuo mining area, with total annual gas drainage over 11.4 million m^3.



Rootes blowers are employed to supply middle pressure coal mine methane to the town gas supply system.

Jiaozuo mining area has a well-established coal mine methane transport and distribution system which is supplying coal mine methane to more than 50,000 household users.

Overview of Jiaozuo Mining Area

Jiaozuo Coal Group
239 Jianfanzhonglu, Jiaozuo
Henan 454002, China
Tel: 0086-391-3531087
Fax: 0086-391-2923274

China Coalbed Methane Clearinghouse
35 Shaoyaoju, Chaoyang District
Beijing 100029, China
Tel/Fax: 0086-10-84610779
Email: cbmc@public.bta.net.cn
Website: http://www.coalinfo.net.cn